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This paper illustrates the interplay between laboratory research on feedback and development of instructional materials. Exploratory work suggests that the products of behavior or "product feedback," are functionally different from differential reinforcement. Product feedback provides the means by which self-correction can take place; differential reinforcement does not. This basic research leads to a particular analysis of feedback in two types of curricula: A writing curriculum that makes use of pencil and paper materials and a spelling curriculum that is part of a larger system of computer assisted instruction. The basic research and instructional implications suggest a need for a program of research on feedback and underscores the importance of discrimination training as a precursor to any skilled performance. (Author)

"Product Feedback"

by

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Instructional Design

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This paper illustrates an important interplay between laboratory research on feedback and development of instructional materials. Exploratory work suggests that the products of behavior or "product feedback," are functionally different from differential reinforcement. Product feedback provides the means by which self-correction can take place; differential reinforcement does not. This basic research leads to a particular analysis of feedback in two types of curricula: A writing curriculum that makes use of pencil and paper materials and a spelling curriculum that is part of a larger system of computer assisted instruction. The basic research and instructional implications suggest a need for a program of research on feedback and underscores the importance of discrimination training as a precursor to any skilled performance.

"Product Feedback"

Pamela Meadowcroft

Introduction

As you have heard from Ms. Doran, operant research on errorless learning grew out of the early applications of behavioral principles in programmed instruction. Low error rates accompanied successful learning of verbal material. Yet the prior theory had dictated the necessity of errors for learning. Terrace (1963) brought this discrepancy into the lab and established an elegant program of research on errorless learning which continues to affect instructional practices and laboratory research.

We now turn to a current gap in our science of behavior. The acquisition and maintenance of behavior by reinforcement is amply supported both in the lab and in the natural environment. It is a well known principle that responses which are followed by positive consequences are strengthened. Even though contingent reinforcement is response produced, little consideration has been given to the products of behavior, such as a spoken word, a sung note, and a printed letter. These products serve as cues for subsequent responding. In this sense the products of behavior are feedback--response produced stimuli that determine the form of future behavior.

In the following talk I will present an interpretative behavioral analysis of product feedback, how this analysis inspired some laboratory research we are currently exploring and the implications for this experimental analysis in instructional practices.

A Behavioral Analysis

Consider an infant learning to talk. Normally skilled speech develops by learning to match self-produced sounds to speech sounds. Discriminations between self-produced sounds and appropriate speech sounds are initially established by the differential reactions of the child's verbal community. At first any approximation to a speech sound meets with parental joy while as these early sounds are established the joy criterion shifts more and more towards correct speech forms. This training involves both the differentiation of the child's own vocal-muscle patterns as well as learning to hear the differences among the sounds these responses produce. In the processes of vocal-muscle differentiation and sound discrimination the child learns the relevant response and stimulus dimensions for his or her particular language.

Eventually reinforcement for correct speech production shifts from the external reinforcing community to more immediate, self-generated sources. This shift makes continued shaping and maintenance of good speech automatic. That is, when the child's "ear" has been trained to discriminate correct speech sounds, he or she can immediately judge the adequacy of self-produced sound as well as correct inappropriate utterances.

Discriminating or judging the adequacy of a self-produced sound determines subsequent behavior. If the sound is judged as adequate, then reinforcement is automatic--no external confirmation is necessary. If the self-produced sound is judged as inadequate,

then a shift in producing a sound closer to the speech sound is initiated. This shift or self-correction is possible because of the child's earlier experience in which an incorrect sound came to serve as a cue for changing the response along the relevant dimensions for that language. The magnitude and direction of change depend on the previously trained sound discrimination. That is, only when feedback sounds have been discriminated can the learner self-correct.

The implications of discriminated feedback stretch across all productive behavior. Even attempts at "remembering" require an analysis in terms of discriminated feedback. We have all had a tip-of-the-tongue experience where an answer or name is almost recalled but not quite. The following scenario borrowed from Adams (1967) would not be uncommon:

> As the subject runs through a series of similar responses he has the clear feeling that he knows the correct response, has it on the tip of his tongue, and can give it in just a moment. Moreover, the subject not only knows he is in error and must reject wrong responses, but also knows the relative magnitude of the errors. For example, a subject might be asked to give the capital of the state of Illinois. He might say, "The capital of Illinois is Bloomington. No that's wrong! Planfield! No, that isn't it either! Summerfield! That's close! Springfield! That's it!" Our subject certainly seems to know what his first

> response is a relatively large error and should summarily be rejected, that the second response has smaller error and is in the general region of the correct response, that the third response is very close to being correct and so on. (Adams, 1967, pp. 284-285)

Here the indivdual tries to recall Springfield. After each approximation the guess is automatically corrected with a shift towards a city that sounds more and more like Springfield.

But what guides this sustained guessing? The currect situation, "What is the capital of Illinois?" is similar to past situations in which the response "Springfield" was externally reinforced by a teacher or by textual material. However, under conditions where reinforcement for "Springfield" is infrequent we can expect other responses that share stimulus elements with "Springfield" to have high probabilities of occurrence. Each of these high probability responses--Planfield, Bloomington, Summerfield--by the speaker are evaluated by the listener, both of whom in this instance are within the same skin. The degree to which the listener discriminates the appropriateness of the guess will determine when guessing stops. The shift of each guess along the "Springfield continuum," takes place because each inappropriate guess serves as a self-prompt for strengthening the next guess. Such automatic shaping by the speaker-listener would not be possible without discriminated feedback and feedback (or self-produced products) will not be discriminated without previous exposure to contingencies in which a response is made and is differentially reinforced.

Experimental Analysis of Feedback

In both the speech and memory examples feedback is in the form of a product produced by the individual. Products of action indicate the degree to which behavior is adequate and consequently can influence the form of future performance. Such a formulation of feedback is descriptively different from simple differential reinforcement in which the correct response is reinforced by some arbitrary stimulus and the incorrect response is not reinforced.

Since our interpretation of feedback differs from traditional behavioral analyses we went to the lab to analyze the effects of self-produced products. The pilot work I will describe and the early data from it suggest that feedback enhances acquisition of productive behavior over and above the effects of differential reinforcement.

Insert Slide 1 about here

Children were trained to respond to five locations on a long response key in the presence of five progressively flatter ellipses. Discriminations among these ellipses had been previously established in a same-different task. In the upper half of this slide the figures illustrate the same-different task in which each child was presented with an ellipse on the center key and a comparison ellipse on the right hand key. They were then told to touch the right hand key if the two pictures were the same or the blank, left hand key if the figures were not alike. In the bottom part of the slide are figures that illustrate the training procedures for learning the five ellipse-

position correspondences. An ellipse was presented in the upper-center key and the children had to find the correct place for this picture along the bottom long key. Touching any of the five areas produced differential reinforcement. A correct response produced a chime and m&m's, whereas pushing the wrong area produced an inter-trial-interval. Some children, in addition to this differential reinforcement, received productive feedback in the form of the ellipse appropriate to the touched area. Learning the correspondences between ellipses and areas when followed by arbitrary reinforcement (chimes and m&m's) was slow; whereas when each response produced an ellipse that was proportional to that response's position along the long key, learning was quite rapid.

On this data slide you see the individual results for learning the ellipse-position correspondences for positions 2 and 4. Each step-up indicates an error on that trial. In the top part of the slide these no-feedback data show many errors; in fact, the first four children never reached the criterion of eight out of ten consecutively correct trials. In contrast, the bottom half of the slide shows all children, whose responses produced ellipse feedback, reached criterion with overall fewer errors. Therefore, only when

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Insert Slide 2 about here

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the ellipse-to-position relation indicated the degree of correctness of the response was learning effective.

Such results are not predicted from operant work. In research on stimulus control responding in the presence of a particular stimulus

is successfully established when reinforcement is differential. Typically, a discrete response, such as pressing one key, is reinforced during the experimental stimulus and not reinforced during other stimuli. This training is particularly rapid when reinforcement is differential and immediate. However, in the above experiment stimulus control by each of the ellipses is established more readily for the feedback condition even though every response in the other condition is differentially reinforced.

We are continuing our look at productive behavior in the lab. This ongoing experimental analysis of feedback bears on operant theory. The evidence suggests some needed expansion of feedback effects. Also this research, inspired by behavioral descriptions of everyday behavior, feeds back into applied problems. It provides the empirical and conceptual base for the following analyses of productive behavior in curriculum materials.

Applied Uses of Feedback

We chose two types of academic skills in different types of curriculum materials to analyze the uses of discriminated feedback. These include printing, in paper and pencil format, and a spelling program from Computer Assisted Instruction (CAI).

Printing. In most instructional approaches to teaching printing the child begins by copying or tracing over model letters (Enstrom & Trafford, 1966; Monroe, 1973; Noble, 1974). Each finished product is then externally approved by the teacher. If the form is not good, the child has no means by which he/she can correct the form unless

additional information is given concerning how the form was bad, how far from good it was, whether the beginning or end strokes were incorrect, and so forth. Such demands for extensive teacher tutorial time inevitably go unfulfilled. Small wonder printing is difficult to learn and judging from many adults' handwriting it seems that very few learn good form.

A better method to teach printing is one that insures discriminated feedback or the discrimination of one's own produced letter forms. If the beginning printer discriminates good form from bad, then he/she can judge the accuracy of their own letters as the letter is being produced. Direct discrimination training of good and bad letter form should be prominent in the early parts of a writing curriculum so that the beginner does not learn bad form.

Skinner and Krakower's (1968) program on cursive writing shows exemplary use of feedback for successful writing. We would expect to find good examples of discriminated feedback in their program because, in the authors' own words:

> "The program stresses the necessity that each child be able to discriminate between badly formed and well-formed cursive letters. Contact with improperly formed letters is a necessary and important part of learning to write. However, the child is never required to <u>form</u> incorrect letters and so never has a chance to acquire bad handwriting habits."

It is an especially interesting curriculum because the program uses paper and pencil materials and yet is able to insure responsiveness

to student behavior. It uses a process called write-and-see in which ink from a special felt-pen reacts with the chemically treated paper so that lines drawn within appropriate bounds turn the paper brown, whereas inappropriate, out-of-bounds lines turn the paper light yellow. Such easily discriminated, differential stimuli provide immediate feedback for appropriate and inappropriate moves of the pen. As the child begins to move the pen carelessly the color of his/her product provides the cues needed for immediate correction. And as the program progresses the "tolerance" or area in which the child can move the pen and still produce brown diminishes. Just like the speech example, the criterion for good form becomes stricter as training proceeds.

Insert Slide 3 about here

The authors also provide key tasks for discrimination training of good form. Group discrimination tasks include having the teacher print on the blackboard several capital and lower case letters and then ask questions that emphasize the dimensions of good and bad form. In this slide, the top example, the teacher asks questions about guide lines--"Does the capital 'A' touch the top line?" "Does the 'c' touch the middle line?" and so forth. In the middle example the teacher asks the children what corrections are required to make these letters better. Good form in both examples follows guide line requirements. In the bottom example the teacher asks questions about proper spacing to help establish needed discrimination for this aspect of good form.

In addition to these teacher directed activities, the program itself exposes the beginners to discrimination tasks. Here is a

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Insert Slide 4 about here

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sample of part of an exercise in which the beginning printers correct the poor letters. As in the whole program if their correction marks are right, the marked paper turns brown; if wrong, the marked paper turns yellow. Here is another exercise sample

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Insert Slide 5 about here

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in which the printers trace-over the best letter. In both exercises the children discriminate good from bad forms. This experience, based on our experimental work and our interpretive analysis of productive feedback, would make self-correction of their own forms more possible. In the production exercises, seen in this slide, the dis-

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Insert Slide 6 about here

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criminating child is able to judge the accuracy of produced letters as the supporting lines are faded out.

Spelling

Another set of instructional materials we analyzed in terms of discriminated feedback is a spelling curriculum developed at the Learning Research and Development Center at the University of Pittsburgh (Block, 1974; Simon and Simon, 1972). This curriculum is part of Computer Assisted Instruction and is called CAI spelling. (For a comprehensive behavioral analysis of these curriculum materials see Holland and Solomon, 1975).

Computer assisted instruction can, in theory, readily meet the requirements for discriminated feedback. The sophisticated technology of the computer makes possible speedy discrimination training of the relevant dimensions for particular skilled production and can immediately provide the product results of subtle changes in behavior.

However, provisions for discriminated feedback in computer assisted instruction are not as well developed as the technology. Often only a "yes" or "no" follows responses and though the appropriate answer may be displayed for comparison with the student's product, the contingencies that establish the discriminative skills that are needed to change or maintain subsequent performance are, many times, lacking.

The TRYSPL program from CAI spelling is a particularly interesting part of the curriculum because it is specifically designed to teach alternative graphemic spellings for a number of words and establish the discrimination of correct and incorrect spellings among these alternatives. We would expect, then, to find good uses of discriminated feedback.

The authors of these materials base their instructional strategy on a "generate-and-test" phonetic process. Here the speller tries out different letters that correspond to the sounds in the word and when finished the word is recognized or discriminated as either correct or incorrect. If an attempted spelling is close enough to the correct one and is discriminated as such, this product, as in

the "capital of Illinois" example, can serve as a prompt for an even closer or correct spelling.

In the generate-and-test process recognition of the spelled word requires previous experience with that word, or words with shared elements, in textual form. Without prior differential learning, the speller cannot discriminate the correctness of the generated spellings. It is no surprise that spelling errors are due to discrimination failures.

Even though experience with the to-be-spelled words is critical for choosing the correct alternative spelling, the TRYSPL program fails to build-in contingencies for word discrimination and thus fails to make efficient use of feedback. A sample of the protocol can be seen on the next slide. "Feedback" as these authors use it

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Insert Slide 7 about here

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include "Good" for a correct response and an appropriate message for an error such as "No," "No, look again," "No, the correct spelling is KNOCK." No information is provided for any of the alternative spellings unless that spelling is chosen as correct. Then this choice is signaled as correct or not. The computer does eventually display the correct spelling which may, incidentally, help in establishing discriminations of appropriate word spellings, but contingencies for explicitly training discriminations among the correct and incorrect spellings are lacking in TRYSPL. We have seen that the alternative spellings can provide discriminated feedback for

correct spelling if the speller has previous relevant experience with the word.

The authors of this curriculum did recognize the need for discrimination training of the spelling words. Consequently, the curriculum was restricted to students who could already read all the spelling words. This target group would then have had necessary discrimination training in their previous reading activities. In addition, another program was created, called SPRUF, that gave direct discrimination training of the spelling words in the curriculum.

Insert Slide 8 about here

In this slide you see sample protocols for SPRUF. Students are given a sentence in which a word is left out such as "sour is to _____ as lemon is to sugar." The appropriate word, "sweet," spelled in four alternative ways, is displayed below the sentence. The child chooses the word he/she recognizes as correct and if the choice is wrong the missed word is presented at the end of the list until all the words are correctly identified. Following this training, the beginning speller would be able to discriminate the correctness of each of his/her spellings during the generate-and-test TRYSPL part of the curriculum. Just as the fellow was able to generate and reject city names until he hit upon Springfield, so too can the speller, with appropriate discrimination training, generate and test the accuracy of his/her own spellings.

Conclusion

Our exploratory research and these curriculum analyses of discriminated feedback provide suggestions both to the curriculum developer and to the laboratory researcher. To the developer: Before a learner can skillfully execute productive behaviors, discrimination training among good and bad products must take place. Then the learner can judge the adequacy of their own products and self-correct. To the researcher: An open ended research program concerned with feedback properties exists.

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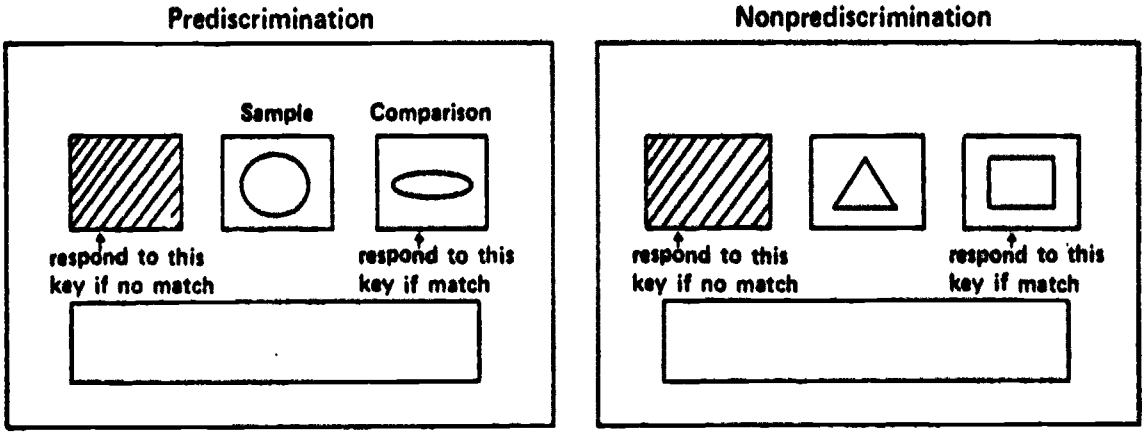
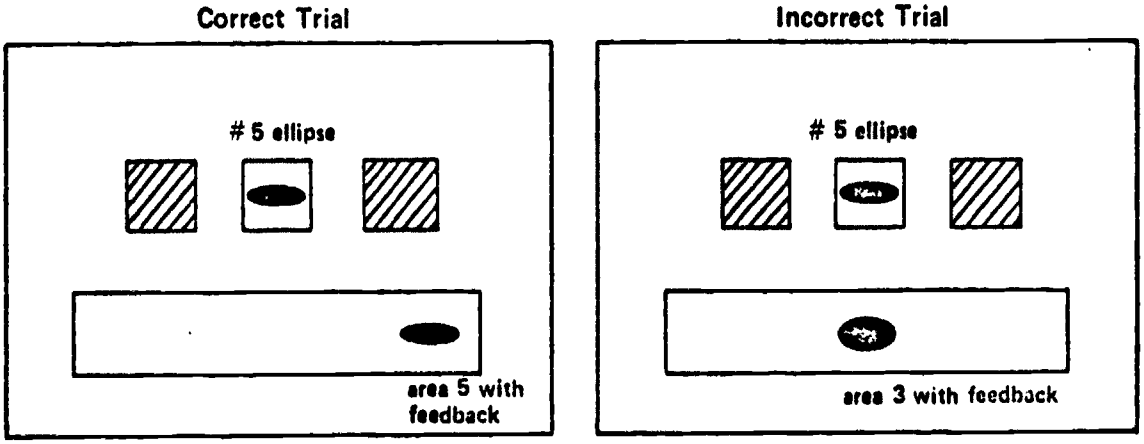
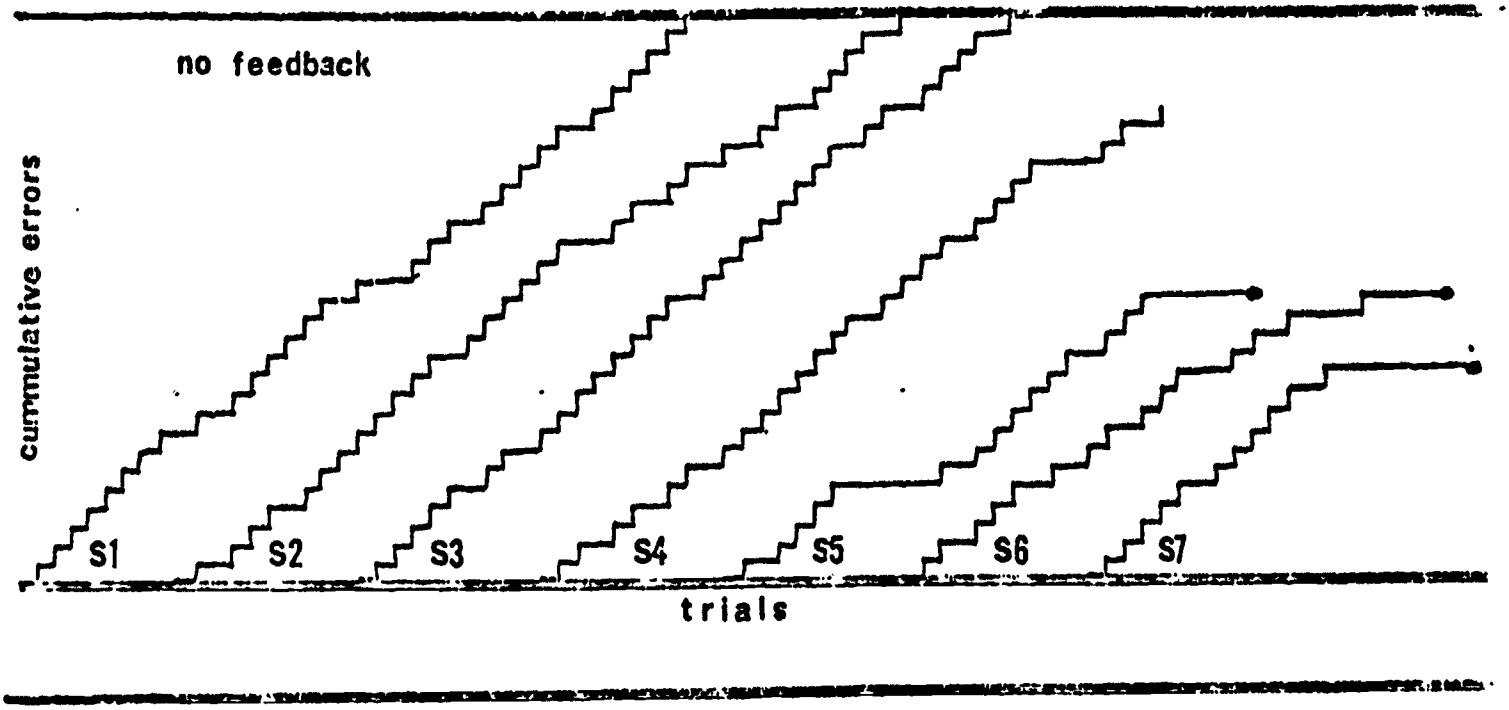
PRETRAINING

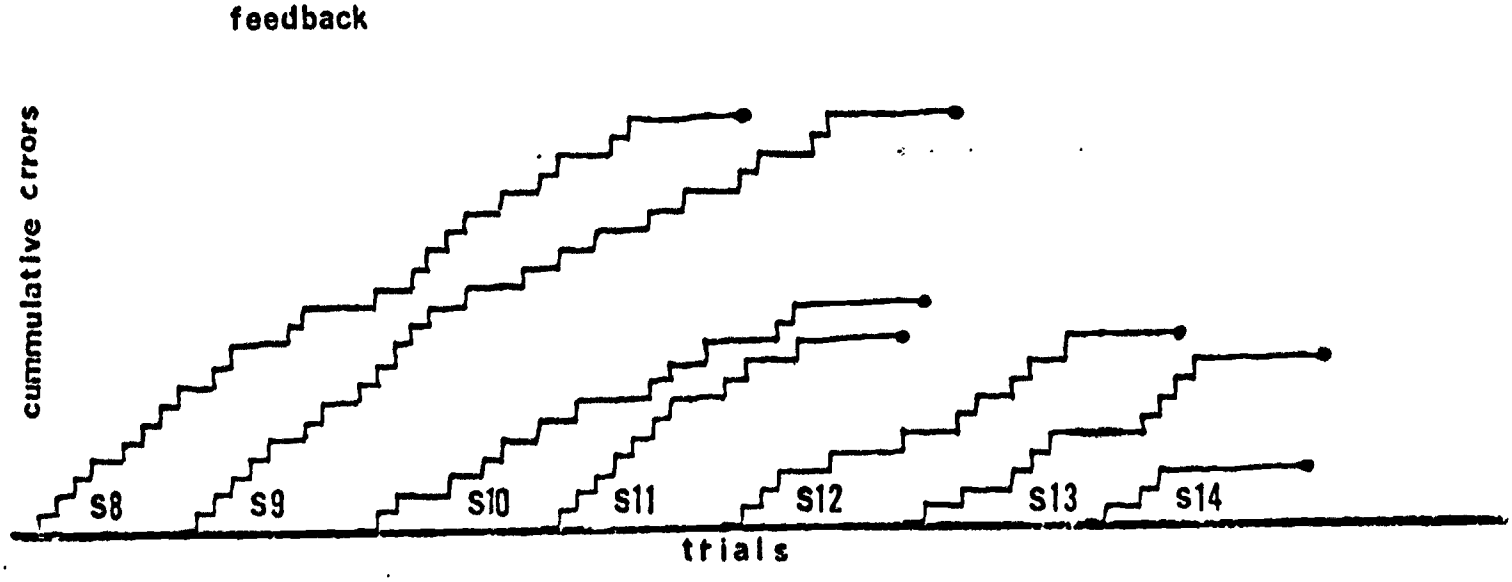


TRAINING



Slide 1


no feedback
cummulative errors
S1
S2
S3
S4
S5
S6
S7
trials


feedback
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S8
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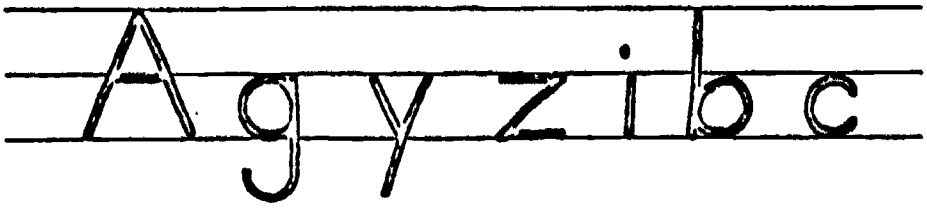
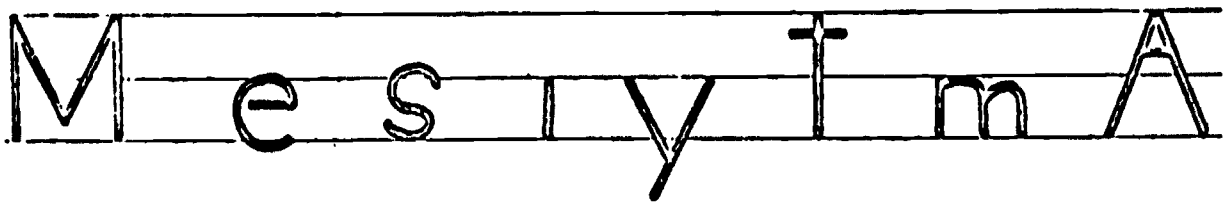
trials

Slide 2

DISCRIMINATION TRAINING



GUIDE LINES

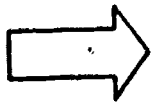


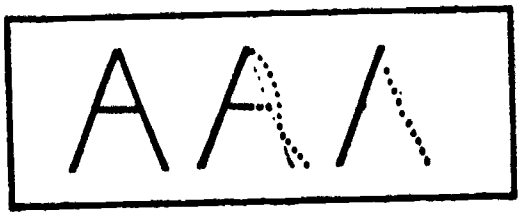
INAPPROPRIATE FORM

This is too little space. T h i s

i s t o o m u c h. Just right.

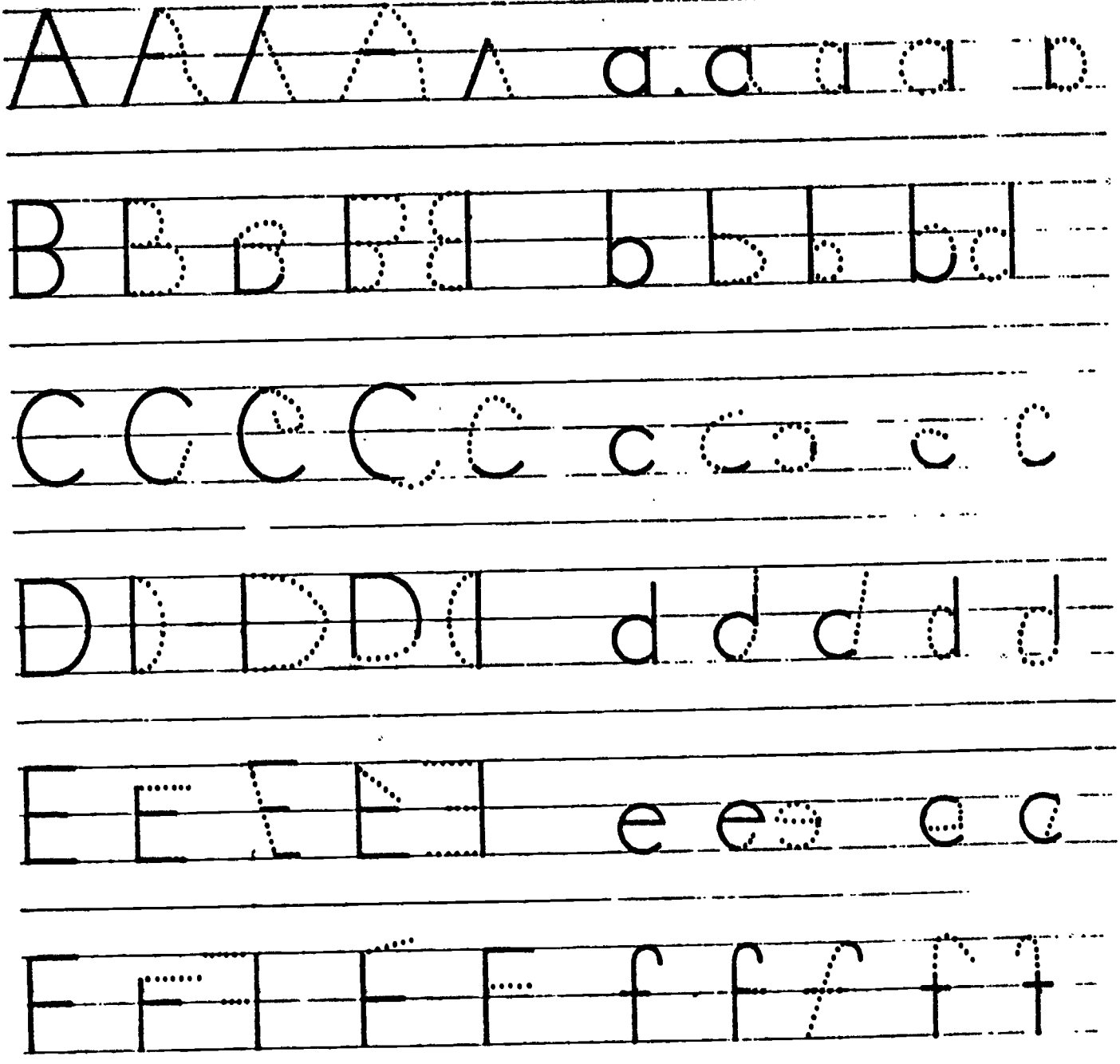
SPACING



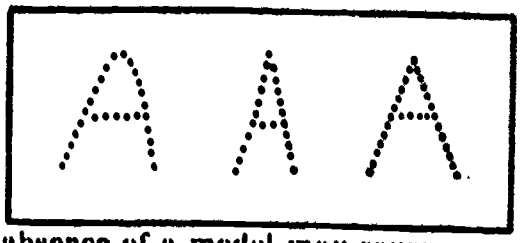


The letters with dots are wrong. Look at the first letter. Make the letters with dots look like the first letter.

Make sure the children complete *four* letters after each model.



Slide 5



Find and write the best letter.

Make sure the children understand the directions. The absence of a model may cause confusion.

A A A A

q q d q

B B B B

b b b b

C C G C

c e c e

D D D D

d d d d

E E E E

e e e e

F F F F

f f f f

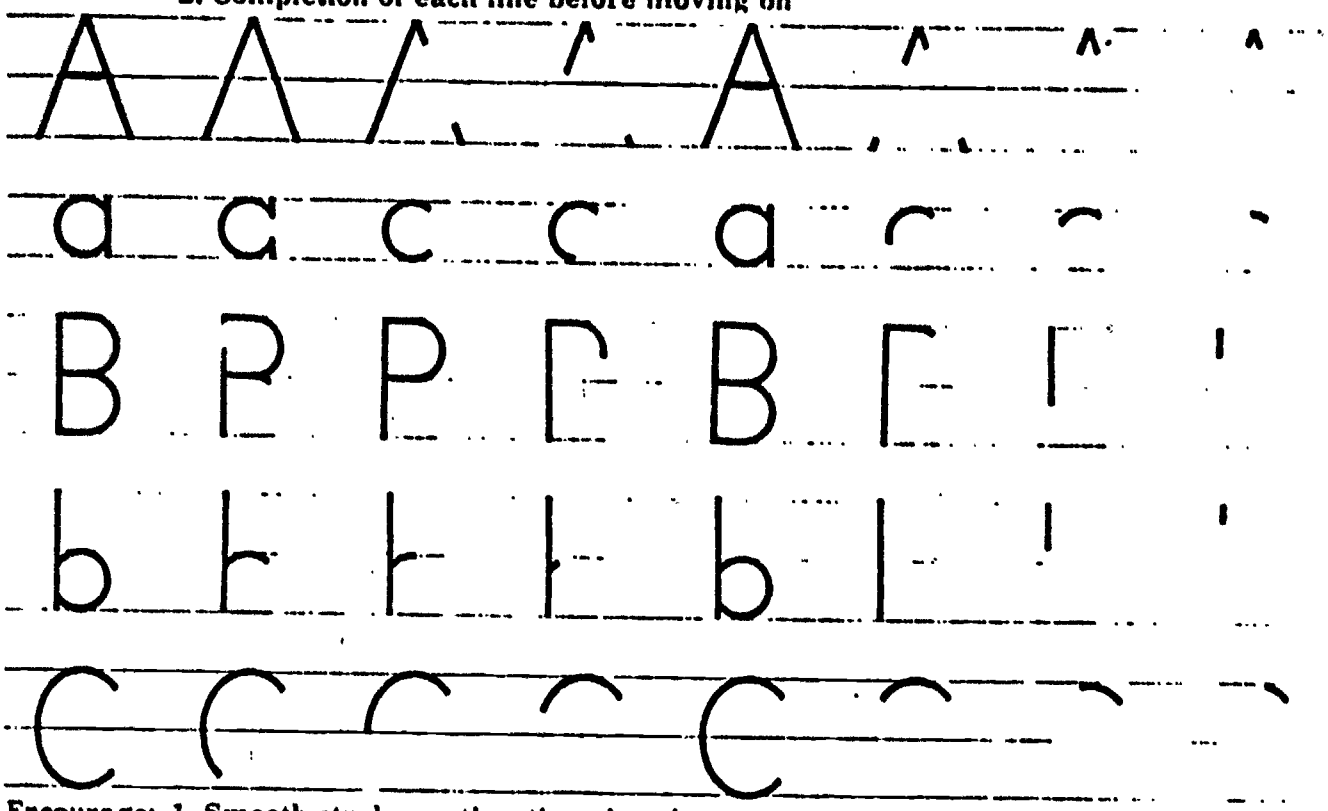
G G G G

g g q g

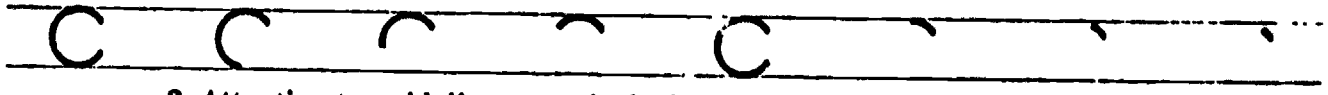
Look at the finished letters on each line.
Make the other letters look like these letters.

Emphasize: 1. Writing from left to right

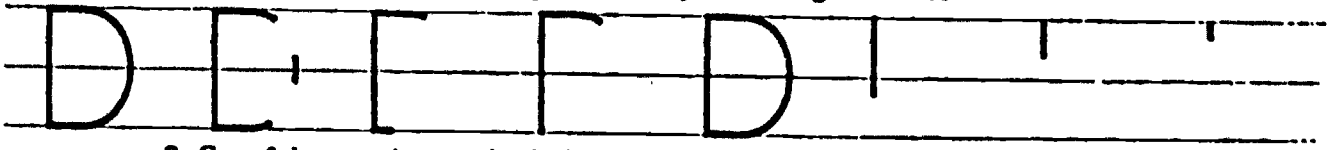
2. Completion of each line before moving on



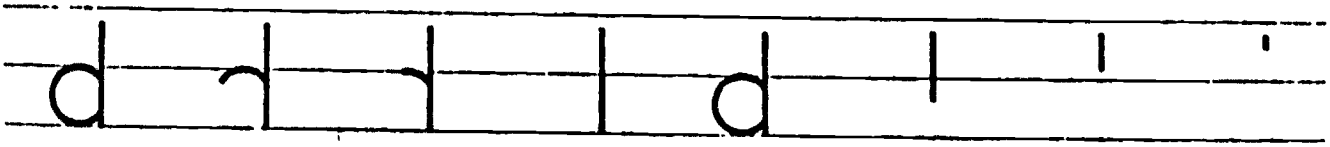
Encourage: 1. Smooth strokes rather than drawing

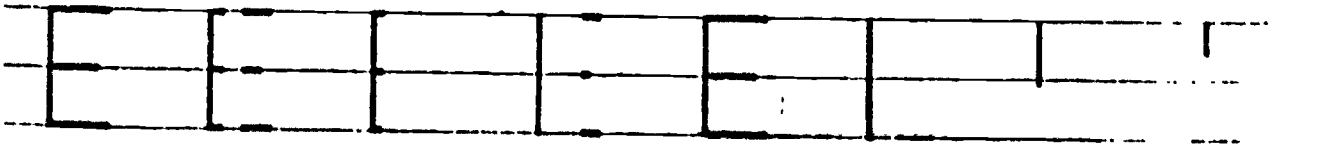


2. Attention to guidelines, particularly middle guidelines



3. Careful attention to the height of the lowercase d





Slide 7

TRY WORD 1:

SPELLING 1? ***nok
SPELLING 2? ***nock
SPELLING 3? ***knock
SPELLING 4? ***no

LOOK AT YOUR SPELLINGS.

TYPE THE NUMBER OF THE SPELLING YOU THINK IS CORRECT.
***2
NO. THE CORRECT SPELLING IS 3 -- KNOCK

COPY THE CORRECT SPELLING FOR WORD 1 ON YOUR WORKSHEET.

PRESS RETURN TO TRY THE NEXT WORD *** (Screen is cleared).

TRY WORD 2:

SPELLING 1? ***half
SPELLING 2? ***haf
SPELLING 3? ***no

LOOK AT YOUR SPELLINGS.

TYPE THE NUMBER OF THE SPELLING YOU THINK IS CORRECT.
*** 1
YES. THE CORRECT SPELLING IS 1 -- HALF

COPY THE CORRECT SPELLING FOR WORD 2 ON YOUR WORKSHEET.

(The program continues in this fashion for the rest of the spelling words on the list).

SPRUF Protocols for sample lessons

Introductory Message

IN THIS EXERCISE YOU WILL SEE A SENTENCE WITH A WORD MISSING
AND A LIST OF WORDS THAT MIGHT BE PUT IN THE BLANK.

TYPE THE NUMBER THAT IS IN FRONT OF THE RIGHT WORD.
PRESS RETURN FOR THE FIRST SENTENCE. ***

Sample lesson -- unit words from spelling text (Student response underlined).

SOUR IS TO .... AS LEMON IS TO SUGAR.

1 -- SWET 2 -- SWETE 3 -- SWEET 4 -- SWEAT

*** 3
YOU ARE RIGHT. 3 -- SWEET IS CORRECT.

PEOPLE SAY THAT A .... WILL EAT TIN CANS.

1 -- GOTE 2 -- GOAT 3 -- GOUT 4 -- GOAD

*** 1
NO. 2 -- GOAT IS CORRECT

Sample lesson -- homophones.

....MEMBERS OF THE CLUB WENT TO THE CONVENTION.

1 -- ET 2 -- ATE 3 -- EIGHT 4 -- AIT
***

WITH HER GLASSES JANE CAN .... CLEARLY.

1 -- SE 2 -- SEA 3 -- CEA 4 -- SEE

***

(Program continues presenting sentences until a correct response is made for each sentence).